

Preliminary Analysis of Blood Lead Levels in Saline County  
and other Selected Areas in Kansas



## **Background**

Lead is found throughout our environment. It is a naturally occurring bluish-gray metal found in small amounts in the Earth's crust. A good amount of lead in our environment comes from human activities including burning fossil fuels, mining, and manufacturing. In the United States, the most common source of exposure for lead-poisoned children is lead-based paint while the majority of adult cases are workplace-related.

The health effects of lead exposure include intellectual and behavioral deficit in children and hypertension and kidney disease in adults.<sup>1</sup> According to the Centers for Disease Control and Prevention (CDC), approximately 250,000 US children aged 1-5 years have blood lead levels (BLL) greater than 10 micrograms of lead per deciliter ( $\mu\text{g}/\text{dL}$ ) of blood.<sup>2</sup> The CDC has recommended that public health actions take place when a child is diagnosed with a blood lead level greater than or equal to 10  $\mu\text{g}/\text{dL}$  or a blood lead level of 25  $\mu\text{g}/\text{dL}$  or greater is found in an adult. However, several studies have shown that there is no safe level for blood lead poisoning.

Lead poisoning is a preventable public health problem, especially in children. Since 1978, federal and state governments have put in place regulations designed to reduce exposure to lead. A steep decline in blood lead levels has followed throughout the country, including in Kansas. The overall geometric mean (GM) of blood lead level in the US population has declined from 2.3  $\mu\text{g}/\text{dL}$  in 1991-1994 to 1.6  $\mu\text{g}/\text{dL}$  in 1999-2002. The highest levels from 1999-2002 were among children aged 1-5 years (1.9  $\mu\text{g}/\text{dL}$ ) and adults aged  $\geq 60$  years (2.2  $\mu\text{g}/\text{dL}$ ).<sup>3</sup>

Kansas Statutes Annotated (KSA) 65-1,200 through 65,1,214 authorize the Healthy Homes and Lead Hazard Prevention Program (HHLHPP) and the Adult Blood Lead Epidemiology and Surveillance (ABLES) program, housed at the Kansas Department of Health and Environment (KDHE) within the Bureau of Environmental Health (BEH), to maintain a database of blood lead tests administered on children and adults living in Kansas. Kansas Administrative Regulation (KAR) 28-1-18 specifies that laboratories must report the results of all blood lead test results to KDHE. In collaboration with the Kansas Environmental Public Health Tracking Program (EPHTP), these programs conduct targeted analyses to improve knowledge about the environmental factors contributing to lead exposure among Kansans.

Because a specific area around the Exide Technologies battery plant has recently been designated as being in non-attainment for the National Ambient Air Quality Standard for lead,<sup>4</sup> the current analysis and report examines blood lead levels in Saline County and other selected areas in Kansas. The current report updates an earlier report on lead poisoning in Saline County. Previous analyses of the blood lead screening data among children had shown a significant difference in the arithmetic mean (AM) blood lead levels between Saline County and the remaining counties of Kansas.

Saline County, Kansas had a population of 53,597 people in 2000 according to the US Census Bureau. This includes 14,042 (26.2%) children under the age of 18 and 39,555 (73.8%)

adults ages 18 and older. According to KDHE classifications of population density, it is considered a semi-urban county because it has between 40 and 149 persons per square mile. The county seat is Salina, the largest city in the county, with a total population of 45,679 people in 2000. This includes 11,847 (25.9%) children under the age of 18 and 33,832 (74.1%) adults ages 18 and older.

## **Methods**

For the childhood blood lead data (children ages 0-16), all tests with a specimen date on or between January 1, 2000 and December 31, 2010 were included in the study. Each record represents a blood test, not an individual. Therefore, an individual may have multiple blood tests included in the database. For the adult blood lead data, all tests with a specimen date on or between January 1, 2000 and December 31, 2009 were included in the study. Again, each record represents a test, not an individual.

Geometric means (GM), rather than arithmetic means, were calculated so that the methodology is consistent with the national methodology and so comparison can be made to national rates. Geometric means are presented for Saline County, the city of Salina (as defined by the 67401 zip code) and categories of population density: frontier (less than 6), rural (6 to 19), densely-settled rural (20 to 39), semi-urban (40 to 149) and urban (150 plus) persons per square mile. Saline County is classified as a semi-urban county. Analysis is also presented for six counties designated by the HHLHPP as at-risk counties based on the density of pre-1978 housing, population density, average household income and the density of the population age 5 and under. The mean values for all tests missing a valid Kansas address are also provided as they may constitute a source of bias for the study results. All statistical analyses were conducted in Stata<sup>®</sup> and SAS<sup>®</sup> statistical software programs.

## **Results**

### *Children*

There were a total of 314,092 blood test records for children ages 0-16 years between January 1, 2000 and December 31, 2010 for the state as a whole. Each record represents a blood test, not an individual. About 24% of the addresses were missing. For the adult blood lead data, there were a total of 79,645 records between January 1, 2000 and December 31, 2009 for the state as a whole. Roughly 18% of the records lack a valid address.

There were 9,164 blood lead test results from Saline County in the HHLHPP database between 2000 and 2010. This represents about 2.9% of all records. The mean blood lead level among children living in Saline County was significantly higher (3.01 µg/dL) than children living in all other counties in Kansas combined (2.86 µg/dL) (Table 1).

<b>Table 1</b> <b>Mean (GM) Blood Lead Levels (µg/dL) Among</b> <b>Children 0 to 16 Years Old by County, 2000-2010</b>			
	Number of observations	Geometric Mean	95% CI
<b>Missing address</b>	74,923	2.42	2.41-2.43
<b>All other counties</b>	229,064	2.86	2.85-2.87
<b>Saline County</b>	9,164	3.01	2.97-3.05

Children living in Saline County had a mean blood lead level (3.01 µg/dL) (Table 1) that was significantly higher than those living in all semi-urban (2.83 µg/dL) and urban (2.62 µg/dL) counties in Kansas but significantly lower than those living in rural (3.61 µg/dL) and frontier (3.55 µg/dL) counties (Table 2).

<b>Table 2</b> <b>Mean (GM) Blood Lead Levels (µg/dL) Among</b> <b>Children 0 to 16 Years Old by Population Density, 2000-2010</b>			
	Number of observations	Geometric Mean	95% CI
<b>Missing address</b>	74,923	2.42	2.41-2.43
<b>Densely-Settled Rural</b>	45,167	3.06	3.04-3.08
<b>Frontier</b>	9,112	3.55	3.51-3.60
<b>Rural</b>	25,808	3.61	3.58-3.64
<b>Semi-Urban</b>	43,330	2.83	2.82-2.85
<b>Urban</b>	114,811	2.62	2.61-2.63

Among counties designated by HHLHPP as “at-risk” counties, Saline County had the second highest mean blood level (3.01 µg/dL) after Shawnee County (3.14 µg/dL). The level was statistically significantly lower than Shawnee County but higher than all of the other program-designated at-risk counties separately (Table 3).

<b>Table 3</b> <b>Mean (GM) Blood Lead Levels (µg/dL) Among</b> <b>Children 0 to 16 Years Old in At-Risk Counties, 2000-2010</b>			
	Number of observations	Geometric Mean	95% CI
<b>JOHNSON</b>	26,621	2.26	2.25-2.28
<b>RENO</b>	7,259	2.74	2.70-2.78
<b>SALINE</b>	9,164	3.01	2.97-3.05
<b>SEDGWICK</b>	34,435	2.84	2.82-2.86
<b>SHAWNEE</b>	18,200	3.14	3.11-3.17
<b>WYANDOTTE</b>	31,590	2.52	2.50-2.55

Children living in the city of Salina, as defined by the 67401 zip code, had a significantly higher mean blood lead level (3.00 µg/dL) compared to children living in all other Kansas zip codes (2.86 µg/dL) (Table 4).

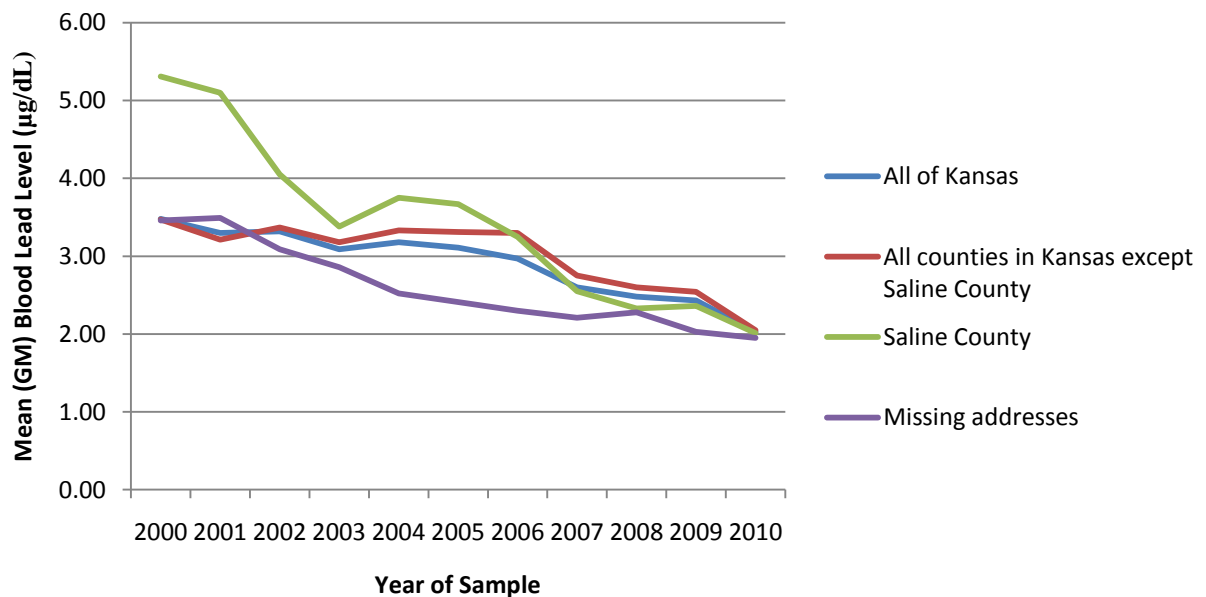
<b>Table 4</b> <b>Mean (GM) Blood Lead Levels (µg/dL) Among</b> <b>Children 0 to 16 Years by Zip Code of Residence, 2000-2010</b>			
	Number of observations	Geometric Mean	95% CI
<b>All other zip codes in Kansas</b>	229,571	2.86	2.85-2.87
<b>67401</b>	8,655	3.00	2.96-3.05

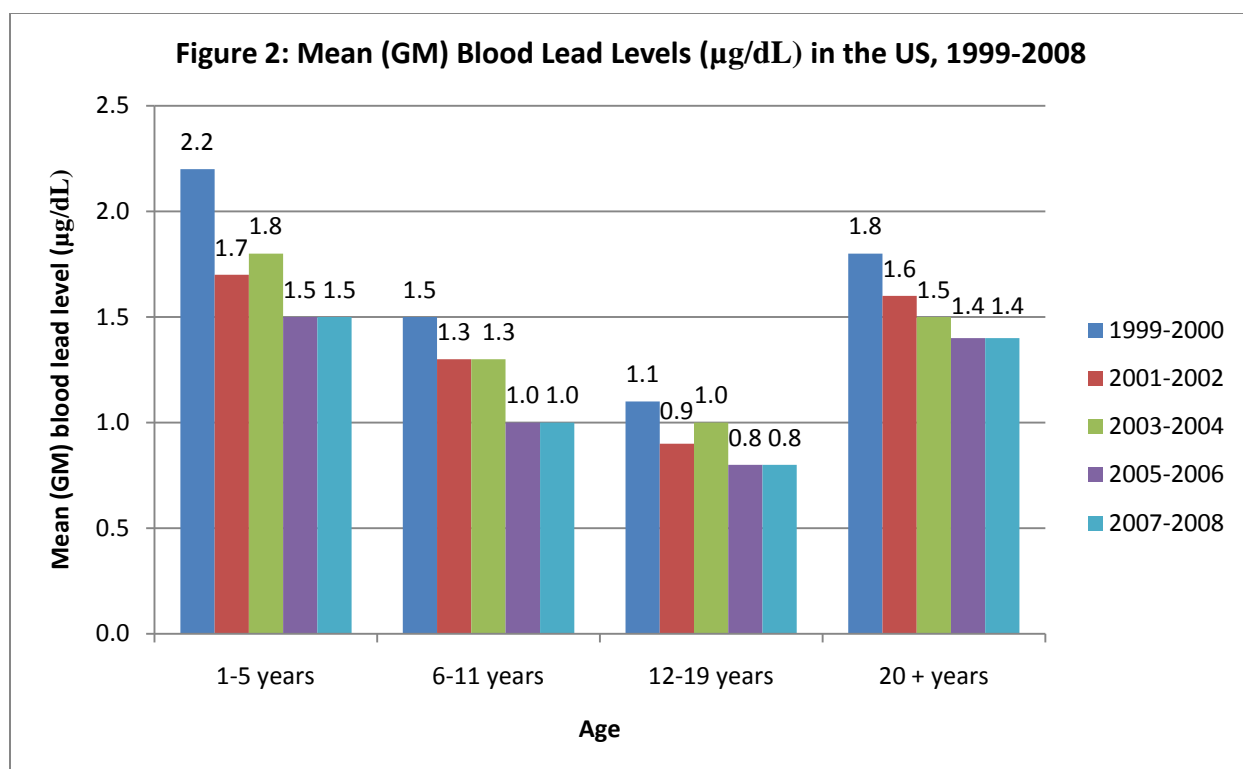
The mean blood lead levels among Saline County children, as well as all children in Kansas, have steadily declined from 2000 to 2010 (Table 5 and Figure 1). This follows a similar pattern of decline seen in the US between 1999 and 2008 (Figure 2).

**Table 5**  
**Mean (GM) Blood Lead Levels ( $\mu\text{g}/\text{dL}$ ) Among**  
**Children 0 to 16 Years Old by Year of Sample, 2000-2010**

	All of Kansas Geometric Mean	All counties in Kansas except Saline County Geometric Mean	Saline County Geometric Mean	Missing addresses Geometric Mean
<b>2000</b>	3.48	3.47	5.31	3.46
<b>2001</b>	3.30	3.21	5.10	3.49
<b>2002</b>	3.32	3.37	4.05	3.09
<b>2003</b>	3.09	3.18	3.38	2.86
<b>2004</b>	3.18	3.33	3.75	2.52
<b>2005</b>	3.11	3.31	3.67	2.41
<b>2006</b>	2.97	3.30	3.25	2.30
<b>2007</b>	2.60	2.75	2.55	2.21
<b>2008</b>	2.48	2.60	2.33	2.28
<b>2009</b>	2.43	2.54	2.36	2.03
<b>2010</b>	2.03	2.05	2.01	1.95

**Figure 1: Mean (GM) Blood Lead Levels ( $\mu\text{g}/\text{dL}$ ) Among**  
**Children 0 to 16 Years Old by Year of Sample, 2000-2010**





### Adults

There were 31,019 blood lead test results from Saline County in the ABLES database between 2000 and 2009. This represents about 39.3% of all records. The mean blood lead level among adults living in Saline County ( $15.58 \mu\text{g}/\text{dL}$ ) was significantly higher than that of adults living in all other counties in Kansas ( $6.54 \mu\text{g}/\text{dL}$ ) (Table 6).

Table 6			
Mean (GM) Blood Lead Levels ( $\mu\text{g}/\text{dL}$ )			
Among Adults by County of Residence, 2000-2009			
	Number of observations	Geometric Mean	95% CI
Saline County	31,019	15.58	15.47-15.70
All other counties	33,902	6.54	6.45-6.62
Missing address	13,949	2.86	2.82-2.91

The same observation can also be made when the county of exposure was considered. Adults who were exposed in Saline County had a mean blood lead level more than two times greater (16.40 µg/dL) than those exposed in all other counties of Kansas (5.15 µg/dL) (Table 7).

<b>Table 7</b> <b>Mean (GM) Blood Lead Levels (µg/dL)</b> <b>Among Adults by County of Exposure, 2000-2009</b>			
	Number of observations	Geometric Mean	95% CI
<b>Saline County</b>	33,847	16.40	16.29-16.52
<b>All other counties</b>	22,701	5.15	5.07-5.23
<b>Tests with no addresses</b>	22,322	4.12	4.06-4.18

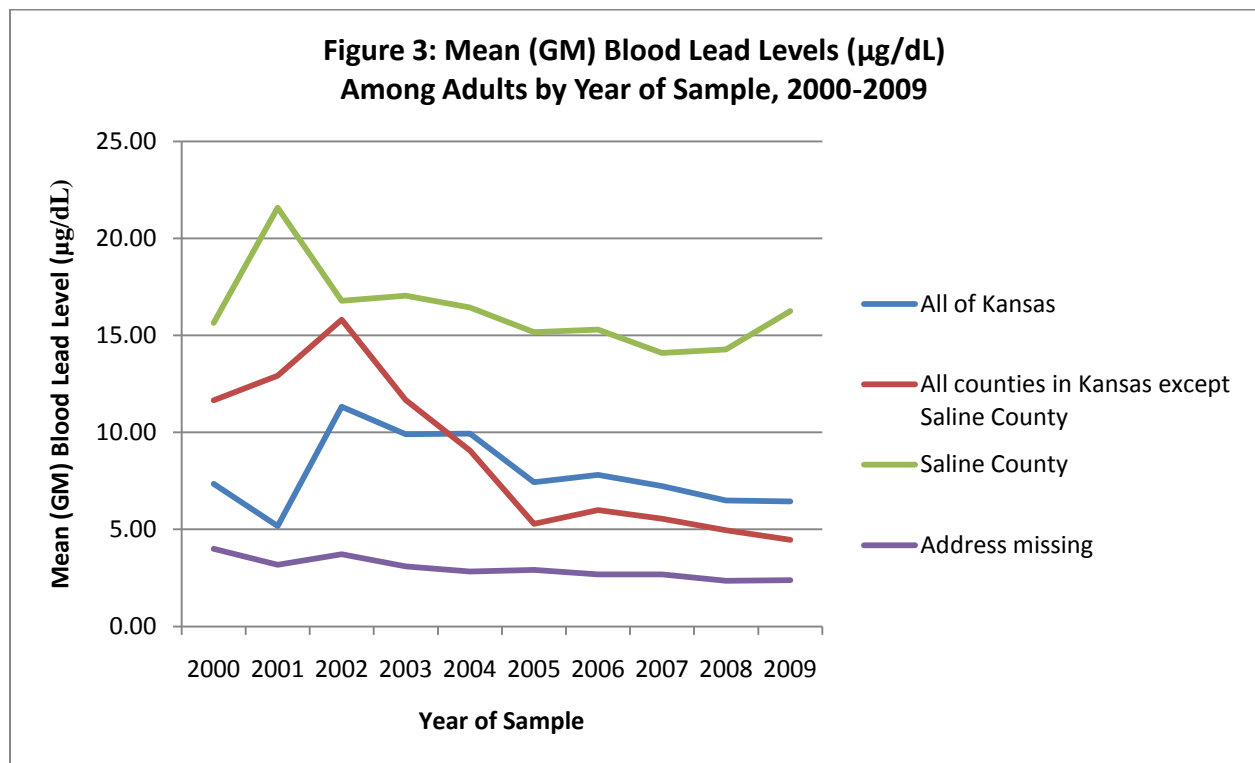
When the zip code of residence was considered, the mean blood lead level of adults living in the 67401 zip code, which represents most of Salina, was more than two times greater (15.60 µg/dL) than for those adults living in all other zip codes in Kansas (6.84 µg/dL) (Table 8).

<b>Table 8</b> <b>Mean Blood Lead Levels(µg/dL)</b> <b>Among Adults by Zip Code of Residence, 2000-2009</b>			
	Number of observations	Geometric Mean	95% CI
<b>67401</b>	29,295	15.60	15.48-15.72
<b>All other zip codes in Kansas</b>	35,600	6.84	6.75-6.93
<b>Tests with no addresses</b>	13,975	2.84	2.80-2.88

Among adults in Saline County, the mean blood lead level remained relatively steady, averaging around 15-20  $\mu\text{g/dL}$  during the ten-year study period (Table 9 and Figure 3). The mean blood lead levels generally declined among adults in the US between 1999 and 2008 with the highest level of 1.8  $\mu\text{g/dL}$  in 1999 (Figure 2).

**Table 9**  
**Mean (GM) Blood Lead Levels ( $\mu\text{g/dL}$ ) Among Adults by Year of Sample, 2000-2009**

	All of Kansas Geometric Mean	All counties in Kansas except Saline County Geometric Mean	Saline County Geometric Mean	Missing addresses Geometric Mean
<b>2000</b>	7.35	11.66	15.65	4.00
<b>2001</b>	5.18	12.93	21.58	3.17
<b>2002</b>	11.33	15.81	16.78	3.72
<b>2003</b>	9.91	11.67	17.05	3.10
<b>2004</b>	9.94	9.07	16.43	2.83
<b>2005</b>	7.43	5.28	15.17	2.92
<b>2006</b>	7.81	5.99	15.30	2.69
<b>2007</b>	7.23	5.55	14.09	2.69
<b>2008</b>	6.49	4.96	14.27	2.35
<b>2009</b>	6.44	4.46	16.25	2.38



## **Discussion**

Based on this analysis, children and adults living in Saline County, Kansas have mean blood lead levels significantly greater than those of the rest of the state. Children and adults living in the city of Salina, represented by the 67401 zip code, had significantly higher levels than the rest of Kansas; among adults, the mean level was more than double that of the rest of Kansas. The mean blood lead level among children in Saline County was significantly higher than those in other semi-urban counties and significantly lower than those in frontier and rural counties. However, the levels among Saline County children, as well as all children in Kansas, have steadily declined from 2000 to 2010. This follows a similar declining trend among children in the general US population between 1999 and 2008.<sup>5</sup> Among adults in Saline County, the mean blood lead level remained relatively steady between 2000 and 2009 despite a decline in the US national average among adults; the levels for Saline County were on average ten times higher than national levels.

It is important to note that this analysis is based on values using various test methods with different levels of accuracy. This may bias the results if one geographic area was using more of a particular test than the others to screen the children. However, at the time of this analysis, there is no indication that this was the case for the period analyzed. It is also important to note that a number of addresses were missing or invalid. This may constitute another source of bias if those missing addresses were not evenly distributed throughout the state. Children receiving federal and state assistance were disproportionately represented among the study population. Therefore the results cannot be generalized to the rest of the population in the state. Finally, the statistically significant differences between mean blood lead levels in Saline County compared to the rest of the state may in fact be due to increased screening and awareness in the county. It is possible that, if data for underrepresented portions of the state were available, the differences between Saline County and the state may not be apparent.

## **Recommendations**

In conclusion, as this analysis does not address sources of exposure; further analyses may be warranted to address potential causes for the increased mean blood lead levels noted in Saline County and in the frontier and rural counties of the state. This could include looking closely at

the childhood blood lead records to identify whether a large proportion of children are living in pre-1950 housing with lead-based paint, whether parents of lead exposed children work in occupations where there is a potential to bring home lead on clothing, shoes and equipment, or whether there are common environmental sources of the exposures. An analysis of adult blood lead records could help identify common occupational or environmental sources of exposure.

If you have concerns about lead exposure in yourself or your family, please contact your local health department or the Kansas Department of Health and Environment, Bureau of Environmental Health at (785) 296-5606.

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## **References**

<sup>1</sup> Agency for Toxic Substances and Disease Registry (ATSDR). Toxicological profile for lead. Atlanta, GA: US Department Health and Human Services, Agency for Toxic Substances and Disease Registry; 1999.

<sup>2</sup> Lead: Topic Home, available at <http://www.cdc.gov/lead/> (Accessed on 06/10/2011).

<sup>3</sup> Centers for Disease Control and Prevention (CDC). Blood Lead Levels — United States, 1999–2002. MMWR Morb Mortal Wkly Rep. 2005 May 27;54(20):513-6.

<sup>4</sup> Environmental Protection Agency (EPA). 2008. Lead Air Quality Standards available at <http://www.epa.gov/air/lead/standards.html> (Accessed on 6/27/2011).

<sup>5</sup> Centers for Disease Control and Prevention (CDC). 2009. National Center for Health Statistics, National Health and Nutrition Examination Survey. Lab 06 nutritional biochemistries (1999-2000); Lab 06 nutritional biochemistries (2001-2002); Blood lead and blood cadmium (2003-2004); Blood lead and blood cadmium (2005-2006); Blood cadmium and lead (2007-2008) available at [http://www.cdc.gov/nchs/nhanes/nhanes\\_questionnaires.htm](http://www.cdc.gov/nchs/nhanes/nhanes_questionnaires.htm) (Accessed on 6/26/2011).